2. On the Presence of Gonadial Grooves in a Medusa, *Aurelia aurita* *. By T. Goodey, Student Demonstrator in Zoology, University of Birmingham.

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(Plate I.†)

While recently examining specimens of the Scyphozoon *Aurelia aurita* in the ordinary course of practical work in the Zoological Laboratory, the structures mentioned in the title of this paper attracted my attention. It was not clear that they formed any part of the ordinary radial canal-system, and, so far, I have been unable to find any account of them in the different text-books and journals which I have consulted in the expectation of obtaining information as to their nature. This being the case, it seemed desirable to investigate the nature and relations of the structures in question and to give a brief account of the results.

The gonadial grooves were found in all the preserved specimens examined in the laboratory, both male and female, and they were also found in living examples which came under my notice during the recent summer vacation.

In a view of the sub-umbrella surface (Pl. I. fig. 1) the four grooves were easily visible to the naked eye, and presented the *appearance* of four radially arranged canals. Each groove (*g.g.*) lies in an inter-radial axis, and is better seen when the prolonged mouth-angles have been removed. It has about the same diameter as the origin of an ordinary per-radial or ad-radial canal, and extends from the central gastric cavity into a gastric pouch (*g.p.*), where it terminates in a somewhat funnel-like expansion at about the centre of the pouch and directly dorsad to the external opening of the corresponding sub-genital pit (*s.p.*). In its course the groove extends along the ventral wall or floor of the passage from the gastric cavity to the pouch and along the floor of the pouch itself.

Bristles could readily be passed along the groove, and by means of a fine pipette a coloured liquid was injected through the groove into the gastric pouch. When the latter became filled and more of the liquid was injected, the excess began to flow back into the gastric cavity through the main opening into the pouch (Pl. I. fig. 2, *d.e.p.*) which is dorsad to, and considerably wider than, the groove in question.

At first sight the grooves appeared to be the beginnings of inter-radial canals ; but the fact that each groove does not extend beyond the centre of each gastric pouch, and also that at this point it widens out and abruptly terminates, negatives this idea.

In order to determine the true nature of these structures, portions of the Medusa, including complete gastric pouches and

* Communicated by Professor Bridge, F.R.S., F.Z.S.

† For explanation of the Plate, see p. 58.

their connections with the central gastric cavity, were removed. These were then stained with borax carmine for forty-eight hours, dehydrated, and embedded in paraffin-wax. Sections were cut at right angles to the inter-radii, passing completely through the pouches from the dorsal to the ventral surfaces. In the above preparation there was a considerable amount of contraction due to the jelly-like consistency of the material, and, for this reason, many of the parts in several of the sections were displaced from their natural relations.

From an examination of the most satisfactory complete sections, however, the nature and relations of the grooves could be easily made out. It was at once evident that they were not closed canals similar to the normal radial canals, and that their resemblance to canals in a superficial or surface view was misleading.

Each groove is, in fact, formed by a folding of the endodermal epithelium lining the floor of the pouch and of its passage of communication with the gastric cavity. This folding is shown in Pl. I. fig. 3, where the epithelium is seen to be raised into two parallel ridges (*e*), one on each side of a median vertical line, which form the somewhat folded lateral walls of the groove (*g.g.*).

In the floor of each pouch, almost completely encircling its outer, lateral, and inner walls, is situated the gonad (figs. 1, 2, & 4, *g.*), in the form of a characteristic incomplete ring of sex-cells, the discontinuity occurring at the point where the groove enters the pouch.

From Pl. I. fig. 4 it will be seen that the endodermal epithelium (e, e^1, e^2, e^3) not only lines the inner surface of the gastric pouch and invests the gonad above, but also extends downwards in the median line so as to form the boundaries of the gonadial groove (*g.g.*). An epithelial stratum (e^4, e^5) also invests the ventral or oral surface of the gonad, and is continuous with that lining the floor of the gastric pouch. Thus the gonad is completely ensheathed by the endoderm from which the sex-cells are derived. As this section passes through the point of discontinuity of the gonad-ring, it will be noticed that the two halves of the ring lie one on either side of a median line along which the gonadial groove passes into the gastric pouch.

The function of these problematic grooves is by no means so easy to determine as their structure and relations. That they have anything to do with the conveyance of food-material from the gastric cavity to the gastric pouches is highly improbable, inasmuch as these cavities are already in free and open communication with one another. A more feasible suggestion is that they function as channels for the outward conveyance of the ripe sex-cells when liberated from the gonads. Their position in the gastric pouches and their somewhat expanded origins in close relations with the encircling gonads, seem to point to this conclusion. The liberated sex-cells would fall on to the floor of a gastric pouch, and the gonadial groove would seem to constitute

an obvious and natural channel for their transit to the exterior. The groove is not closed dorsally, it is true, but the epithelial ridges bounding the groove seem capable of approximating sufficiently closely that it is by no means difficult to imagine the groove as practically a closed canal—a functional gonoduct, in short.

It must be admitted that I have not been able to detect the presence of sex-cells in the gonadial grooves, but this may be due to the fact that the gonads were not mature, or the sex-cells ripe for extrusion. It remains for further investigation to ascertain on living specimens under suitable conditions whether these views as to the nature and function of the gonadial grooves are correct.

A careful examination of *Pelagia noctiluca* and *Chrysaora isosceles*, both of which belong to the Pelagidæ, failed to reveal the existence in either species of any structures comparable to the gonadial grooves of *Aurelia aurita*.

In conclusion, it may be suggested that the observations recorded above possess certain features of more general interest.

In discussing the evolution of the cœlom Sir Ray Lankester* remarks:—"We may suppose the first cœlom to have originated by the closing or shutting off of that portion of the general archenteron of Enterocœla in which the gonads develop, as in *Aurelia* or as in Ctenophora"; and, further, "the most important developments of the cœlom are in connection with the establishment of an exit for the generative products through the body-wall to the outer world." If, therefore, my observations and inferences as to the nature and function of the gonadial grooves be correct, it is obvious that in this organism we have an extremely interesting and primitive condition.

The gastric pouches are special portions of the archenteron, from the walls of which the gonads have their origin; they are, in fact, primitive gonocœles, although not yet completely shut off from the general archenteric cavity as is the case in so many Cœlomata. On the other hand, the gonadial grooves may be regarded in the light of incipient cœlomoducts or gonoducts which in like manner are still but imperfectly constricted off from the archenteron. Consequently the gonadial grooves and gastric pouches of *Aurelia* seem to represent a very primitive stage in the evolution of both gonocœles and gonoducts.

It has generally been held that, with one exception, the Cœlenterata have no specially differentiated genital ducts, the sex-cells finding their way to the exterior either directly by the external dehiscence of the gonads, or indirectly by internal dehiscence into archenteric canals or spaces and thence outwards through the mouth. The single exception referred to is in the case of *Ctenoplana korotneffii*, the aberrant Ctenophor discovered by Willey† in 1896 in the Eastern Archipelago of British New Guinea, in which, however, only male gonads were found.

* A Treatise on Zoology, part ii. 1900, p. 9.

† Quart. Journ. Micros. Science, vol. 39, n. s. 1896–97.

According to the discoverer, the two pairs of gonads apparently had their origin from endodermal cell proliferations of the walls of genital diverticula of the general archenteric canal-system, as in so many other Cœlenterata. Special genital ducts are present, but variable in number, and they are described as being continuous with the tunica propria investing the gonads. The external apertures of the ducts are situated on the dorso-lateral surfaces of the body, below several of the ctenophoral bands.

In the present state of our knowledge of the genital ducts of *Ctenoplana korotneffii*, and especially in the absence of any information as to their mode of origin, any attempt to discuss the question of their morphological character would be of little value. It may therefore be concluded, at any rate provisionally, that, while both *Aurelia* and *Ctenoplana* stand alone among living Cœlenterata in possessing genital ducts, it is nevertheless only in the Scyphozoon that these structures can at present be regarded as cœlomic or archenteric derivations, and, in fact, are a very primitive form of cœlomoduct or gonoduct.

I am indebted to Professor Bridge for the kindness and consideration which he has shown to me in these my first attempts at independent investigation, and also to Mr. F. W. Crispe for the material help given in the preparation of the sections.

EXPLANATION OF PLATE I.

Gonadial grooves in *Aurelia aurita*.

Fig. 1. Surface view of sub-umbrella aspect of *Aurelia aurita*, the prolonged mouth-angles having been removed. The gonadial grooves are shown, and also their relations to the surrounding structures.

Fig. 2. Semi-diagrammatic, enlarged three times. The gastric pouch has been cut through along the inter-radius, and the drawing represents a view taken in the vertical plane. The space between the dotted line and the body-wall represents the course of a gonadial groove from the gastric cavty to its opening into the gastric pouch.

Fig. 3. (× 20) Section passing through the main passage to a gastric pouch, showing the gonadial groove lying in a median position in the ventral wall, bounded on either side by an endodermal epithelial fold.

Fig. 4. (× 20) Section passing through a gastric pouch, showing a gonadial groove in the floor, and the loops of the gonad ring bounding it on every side.

Reference Letters.

b.w., body-wall; *d.e.p.*, dorsal entrance to a gastric pouch; *e.* (fig. 3), epithelial folds; *e*, e^1, e^2, e^3, epithelium lining inside of pouch and covering gonad above; e^4, e^5, epithelium of ventral surface of the gonad and of the floor of a gastric pouch; *g.*, gonad; *g.g.*, gonadial groove; *g.p.*, gastric pouch; *m.p.*, main passage from the gastric cavity to a gastric pouch; *s.p.*, sub-genital pit.

[*March 9th*, 1908.—Since writing this paper my attention has been directed by Mr. E. T. Browne of University College, London, to a paper published by L. Agassiz in 'Contributions to the Natural History of the United States,' vols. iii. & iv. 1860–62, dealing with *Aurelia flavidula*, which is now considered to be the same as *Aurelia aurita*.

In his account L. Agassiz explains that the gastric pouches